

What is claimed is:

- Sab 1>* 1. A method for rapid thermal processing (RTP) of a substrate used to make semiconductor devices comprising the steps of:
 forming a hot gas stream whose power density is above about 5×10^7 W/m²; and
5 moving a substrate through the hot gas stream at a speed selected to treat the surface of the substrate at a high temperature while preserving a temperature differential throughout the thickness of the substrate to enable the substrate to produce enhanced cooling of a treated area of the substrate after the treated area has passed out of the hot gas stream.
2. The method as claimed in claim 1 wherein the power density of the hot gas stream is above about 8×10^7 W/m².
3. The method as claimed in claim 1 wherein the exposure time t_E of said treated area of the substrate to the hot gas stream is less than a value given by the expression: $t_E < \rho c_p \Delta h^2 / 27k$.
- C2* 4. The method as claimed in claim 1 wherein the velocity of the substrate relative to the hot gas stream is above about 1.0 m/sec.
- Sab 3>* 5. The method as claimed in claim 1 for a silicon substrate wherein the velocity of the substrate is selected sufficiently high to yield an exposure time of the substrate to the hot gas stream of less than about 8ms.
- C2* 6. The method as claimed in claim 2 wherein the velocity of the substrate is above about 1.5 m/sec.
- Sab 4>* 7. The method as claimed in claim 1 wherein said substrate is held in a substrate holder of the non-contact vortex type and wherein said substrate holder

*Sub P1
Concl'd. 7* has an extension beyond the substrate edge, said extension extends out from the substrate for a distance greater than the characteristic width of the hot gas stream treatment area.

5 stream treatment area.

C2 8. The method as claimed in claim 1 and further including the step of doping of the semiconductor substrate by annealing of the crystal damage from a previous implantation of doping atoms.

9. The method as claimed in claim 1 and further including the step of diffusing doping atoms from a layer deposited over the substrate.

Step 15 10. The method as claimed in claim 1 and further including the step of diffusing doping atoms from the hot gas stream wherein a material containing the doping atoms were injected into the hot gas stream.

C2 11. A method for rapid thermal processing (RTP) of a substrate used to make semiconductor devices comprising the steps of:

forming an atmospheric arc-type hot plasma stream whose power density is above about 5×10^7 W/m² and has a cross-sectional area that is substantially

5 less than the surface area of the substrate to be treated by the hot gas stream; and

moving a substrate through the hot gas stream with a predetermined controlled pattern and at a speed that is above threshold level selected to treat a surface of the substrate at a high temperature while preserving a temperature differential throughout the thickness of the substrate to significantly contribute to a

10 cooling of a treated area of the substrate after the treated area has passed out of the hot atmospheric gas stream.

12. The method as claimed in claim 11 wherein said threshold level is at about 1.5 m/sec.

13. A method for rapid thermal processing (RTP) of a substrate used to make semiconductor devices comprising the steps of:

forming a hot gas stream whose power density is sufficiently high to increase the surface temperature of the substrate at a rate in excess of about 10^3 °C/sec; and

moving a substrate through the hot gas stream at a speed selected to treat the surface of the substrate at said high temperature while preserving a temperature differential throughout the thickness of the substrate and enable the substrate to cool the treated area at a rate of at least about 10^3 °C/sec after the treated area has passed out of the hot gas stream.

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14. The method as claimed in claim 13 wherein said hot gas stream has a power density that is sufficiently high to raise the temperature of the surface of the substrate to above about 1000 °C during movement of the substrate relative to said hot gas stream without permanent deformation of the substrate and without introducing crystal defects into the substrate.

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15. The method as claimed in claim 14 wherein the power density of the gas stream is above about 5×10^7 W/m².

16. The method as claimed in claim 13 wherein said hot gas stream has a power density that is sufficiently high to raise the temperature of the surface of said substrate along a path to a level at which a shallow segment of the substrate melts along said path.

1.7 The method of claim 13 wherein the motion of said substrate is controlled so as regulate the peak temperature of the surface of the substrate.

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18. The method of claim 13 wherein said movement of the substrate is controlled to provide multiple overlapping passes with sufficient intervals between adjacent passes to enable a portion of the substrate exposed to the hot gas stream during a previous pass to cool to a desired level for a generally uniform thermal treatment of the entire substrate.
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 19. The method as claimed in claim 13 wherein said substrate has a motion configuration wherein the substrate moves through the hot gas stream with a step and scan motion such that the substrate moves with sequential, off-set passes through the hot gas stream with a controlled velocity along linear paths.
 20. The method as claimed in claim 13 wherein said substrate has a motion configuration wherein the substrate moves through the hot gas stream with a step and scan motion such that the substrate moves with sequential, off-set passes through the hot gas stream with a controlled velocity along paths that are arcuate.
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 21. The method as claimed in claim 13 wherein the motion of the substrate is along overlapping scans to provide a greater cool-down time between scans with sets of scans where:
 - scans in each set is greater than the characteristic width of the hot gas
 - treatment area;
 - the subsequent sets of scans are offset by sufficiently small steps to give uniform treatment and
 - sets of scans are run to fully treat the entire substrate.